

Chapter 5



Fine Mass Concentrations

The CASTNet visibility network began collecting aerosol samples in 1993 from sites that span the eastern United States. During 2000, major constituents of the aerosol samples were sulfate, organic carbon, and nitrate. Sulfate (as ammonium sulfate) contributed approximately 50 percent or more of the mass at all eight sites. No significant trend is evident in the data collected over the seven years. Measurements of trace metals designated by EPA as hazardous air pollutants (HAP) were very low.

Figure 5-1 depicts the locations of the eight visibility monitoring sites. All but two sites (Sikes, LA, and Livonia, IN) are collocated with standard CASTNet dry deposition sites. The principal element of each visibility site is an aerosol ($PM_{2.5}$) sampling system consisting of three separate single-stage filters (Figure 5-2). Sampling and laboratory methods were described in the 1998 and 1999 CASTNet Annual Reports (Harding ESE, 1999 and 2001a, respectively).

Single-stage filter packs with cyclones were used to sample $PM_{2.5}$. Teflo[®] filters were used to measure mass and trace/crustal elements. Nylon filters were used to measure SO_4^{2-} and NO_3^- . Quartz filters were used to measure organic and elemental carbon.

Figure 5-1. Locations of CASTNet Visibility Monitoring Sites



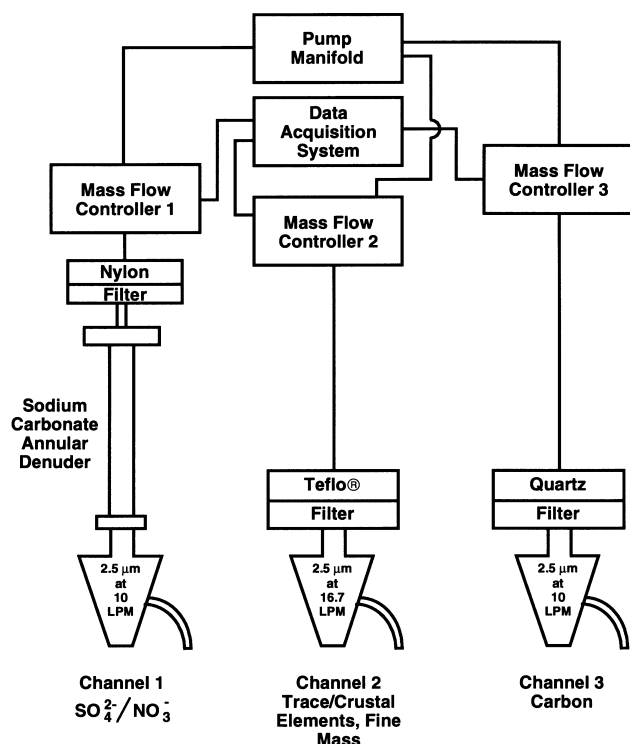
Figure 5-2. Aerosol Sampling System

Figure 5-3 presents 2000 annual and quarterly means of 24-hour $PM_{2.5}$ concentrations measured at the eight visibility sites. Peak 24-hour concentrations measured during each quarter and for the year are plotted in Figure 5-4. During 2000, the highest 24-hour peak concentrations were generally observed during the fourth quarter. On the other hand, the highest quarterly means were generally observed during the third quarter.

Figure 5-5 presents a map of 2000 annual means of reconstructed fine mass. The data are displayed in the form of a pie chart for each of the eight sites. The numerical value outside the pie is the corresponding measured $PM_{2.5}$ concentration. The fine mass was reconstructed using the parameters recommended by Sisler *et al.* (1996) and discussed in more detail for CASTNet by Lavery and Howell (2000). Sulfate (as ammonium sulfate) was the major contributor to fine mass at all sites. Organic carbon and nitrate were also important contributors. Figure 5-6 presents maps of pie charts of 2000 quarterly mean reconstructed fine mass. The highest quarterly means were measured during the third quarter at all but three sites – BVL530, LIV573, and ARE528. SO_4^{2-} concentrations peaked in the third quarter. Organic carbon was a large component of fine mass, especially in the warmer seasons

and regions of the country. NO_3^- was relatively important at sites in colder climates and during the colder quarters. The values in Figure 5-6 are consistent with the geographic and seasonal distribution of NO_3^- measured in the dry deposition network. (See also Appendix B.)

Figures 5-7 through 5-14 present time series of quarterly mean values of measured $PM_{2.5}$ and its reconstructed chemical constituents for each CASTNet site over the period beginning fourth quarter 1993 through fourth quarter 2000. Also shown in each figure are the annual mean and peak 24-hour values for that site. The figures are sequenced beginning in the northeast and moving to the southwest, i.e., from Connecticut Hill, NY (CTH510) to SIK570. The measured mean $PM_{2.5}$ concentration is indicated by the diamonds. The time series of the quarterly means (shown in the top half of the figures) for the eight sites are fairly similar in that quarterly $PM_{2.5}$ values follow the annual cycle of SO_4^{2-} , which peaks in the summer months. However, the relative contributions of organic carbon and NO_3^- were variable from site to site and season to season.

The charts in the lower half of each figure illustrate annual mean and peak 24-hour concentrations of $PM_{2.5}$ and its constituents. Annual values are not presented for 1996 because the network was halted temporarily at the request of EPA. Sulfate contributed approximately half of the mass at the three western most sites and a larger fraction at the other five sites. No trend is evident in the quarterly and annual mean concentrations.

The peak 24-hour values were based on the availability of both measured $PM_{2.5}$ and reconstructed mass for those 24-

The major constituents of $PM_{2.5}$ were sulfate, organic carbon, and nitrate. Sulfate (as ammonium sulfate) contributed at least 50 percent of the mass at all eight sites. Organic carbon was a large component, especially in the warmer seasons and regions of the country. NO_3^- was relatively important in colder climates and colder quarters.

hour periods. The peak 24-hour concentrations were selected based on the peak $PM_{2.5}$ values for each year. The

highest 24-hour concentrations ranged from about 22 to 69 $\mu\text{g}/\text{m}^3$. The highest concentrations were usually observed in the third quarter when sulfate values were at their maximum.

Annual means of $\text{PM}_{2.5}$ mass, sulfate, nitrate, and organic carbon concentrations were aggregated over the eight visibility sites. Values for 1996 were interpolated from adjacent years, i.e., using the same procedures discussed in Chapter 1. Missing quarterly data were interpolated from adjacent quarterly data. Annual means were calculated from data from four quarters. Aggregated annual means are plotted in Figure 5-15. The composite means of $\text{PM}_{2.5}$ mass show no evidence of trends. However, the composite ammonium sulfate values suggest a small downward trend over the seven years.

Annual means aggregated over the eight sites show no trend, with the exception of SO_4^{2-} , which shows a slight downward trend.

EPA has designated 11 trace metals as hazardous air pollutants (HAP): antimony (Sb), arsenic (As), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), and selenium (Se). Eight of these (excluding Sb, Co, and Se) are considered to be priority HAP in the new integrated urban strategy. Teflo® filters that are exposed for 24 hours at the eight CASTNet visibility sites are analyzed via X-ray fluorescence (XRF) for trace elements. The XRF analysis produces information on concentrations of nine of the trace metals that are regulated by EPA. These nine metals include As, Cd, Co, Cr, Pb, Mn, Hg, Ni, and Se.

Annual mean concentrations were calculated for a composite 8-station database for the 7-year period. The same procedure was used to interpolate the trace metal data as was used for interpolating missing $\text{PM}_{2.5}$ and chemical component data. However, 60 percent data completeness was required for a valid quarterly average instead of the 70 percent required for filter pack concentration data.

Concentrations of trace metals, which have been designated as HAP, were very low.

Figure 5-16 depicts annual mean concentrations for six of the nine metals. The three metals (Cd, Hg, and Co) that are not shown had zero (non-detect) concentrations from the XRF analyses for all years. Concentrations of lead were the highest of the six metals, with mean concentrations ranging up to approximately 5.0 ng/m^3 .

Figure 5-3. Annual and Quarterly Mean Concentrations ($\mu\text{g}/\text{m}^3$) of Fine Particle Mass for 2000

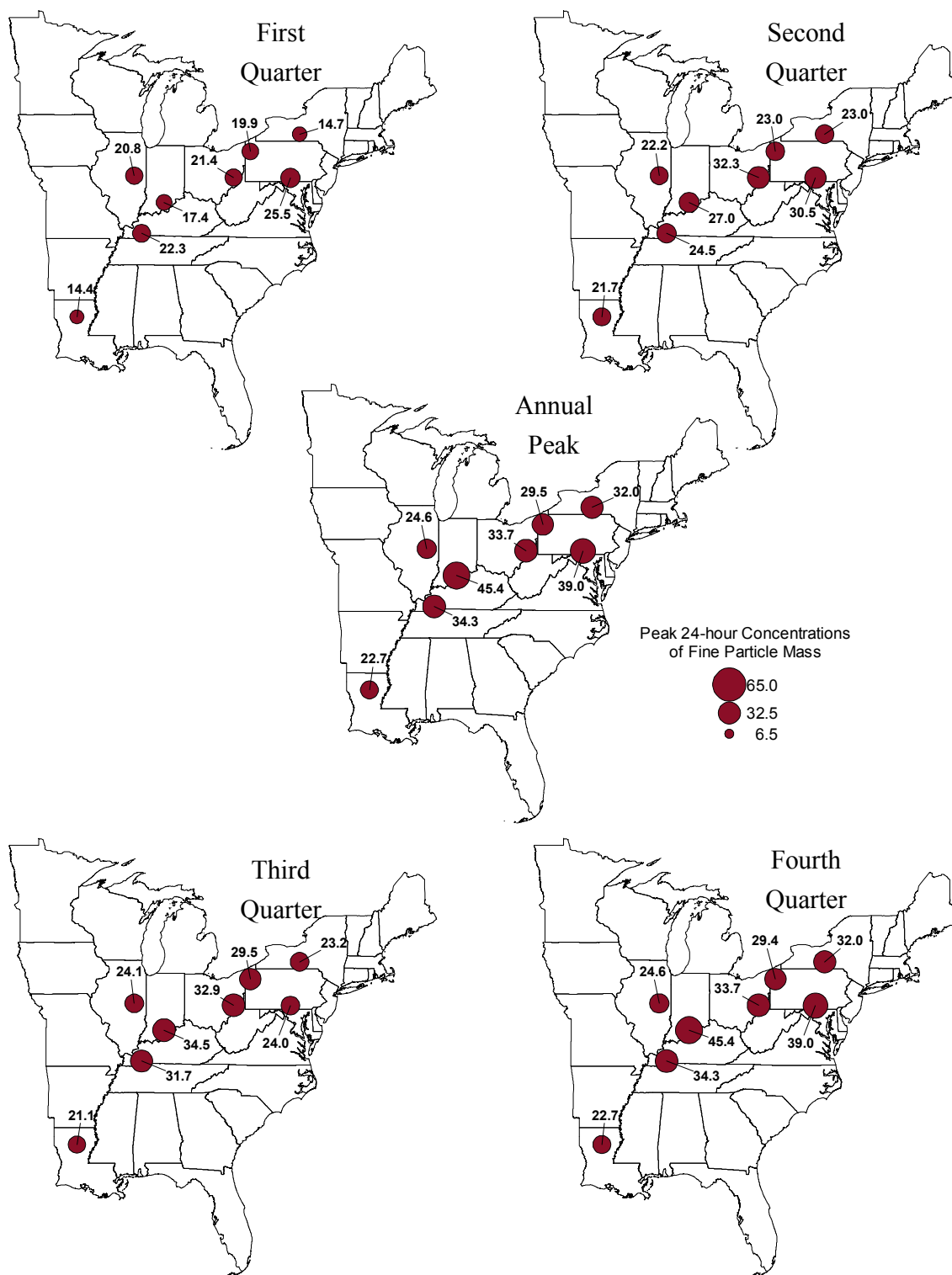
Figure 5-4. Annual and Quarterly Peak Concentrations ($\mu\text{g}/\text{m}^3$) of Fine Particle Mass for 2000

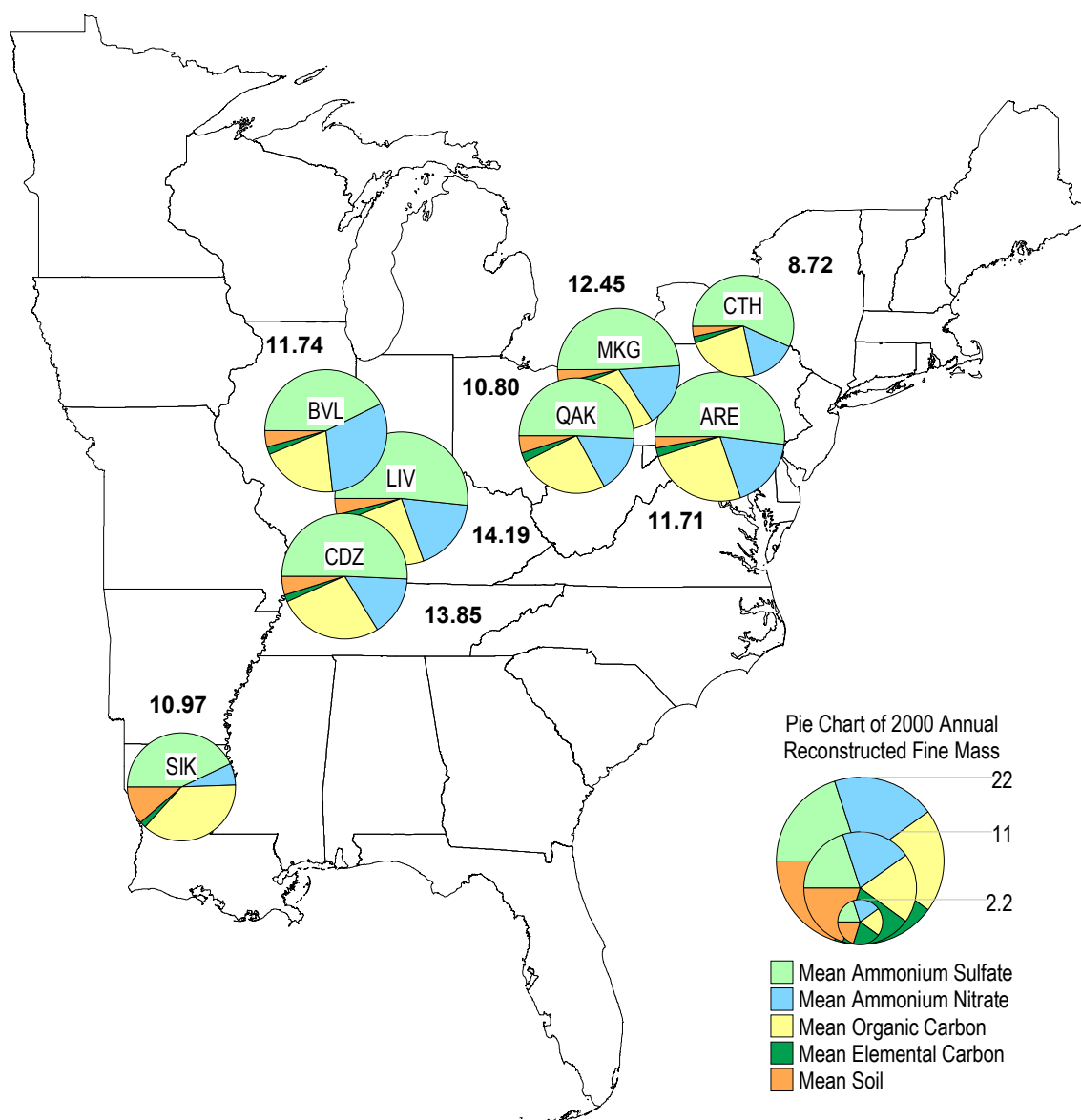
Figure 5-5. Annual Mean of Reconstructed Fine Mass ($\mu\text{g}/\text{m}^3$) for 2000

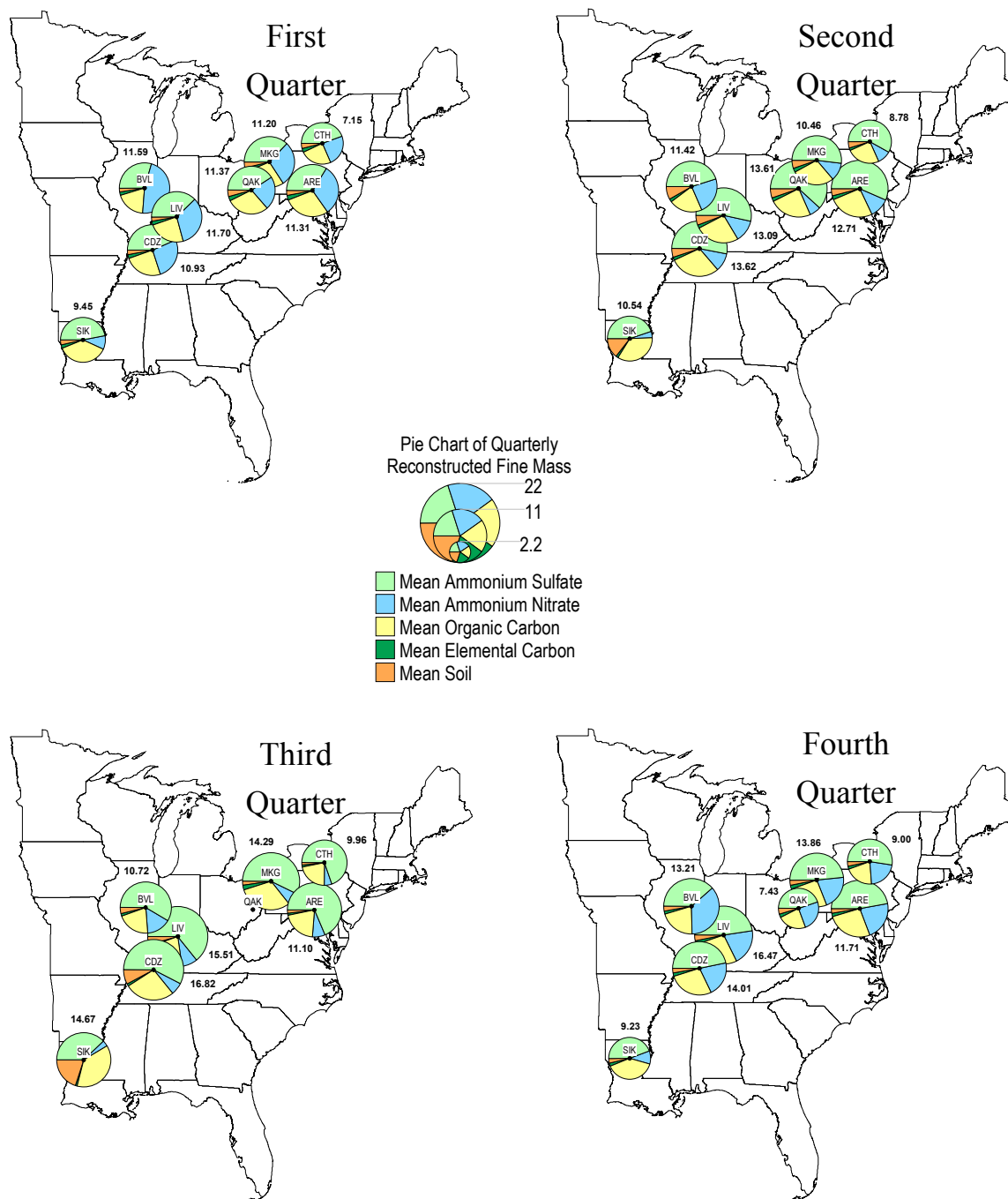
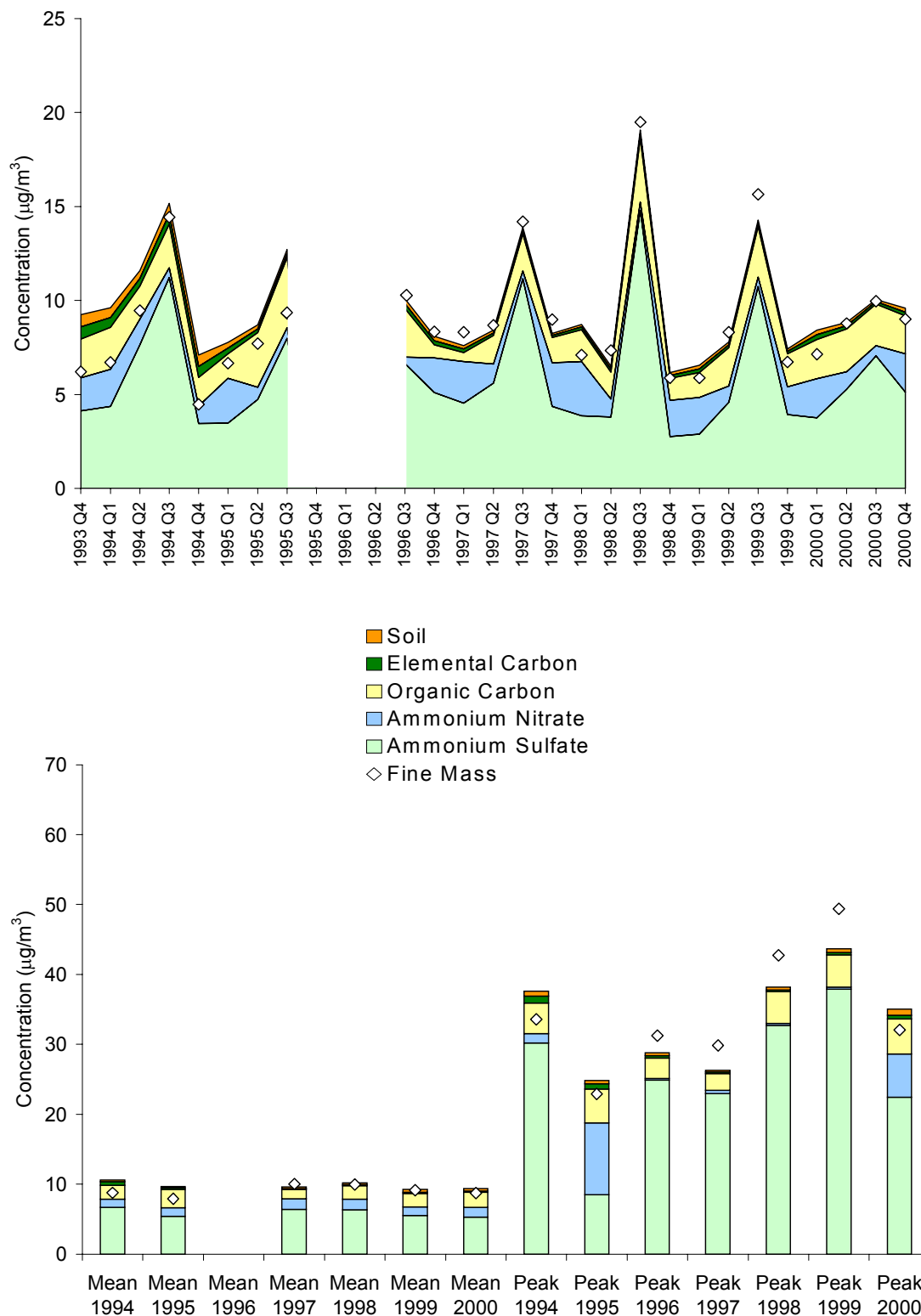
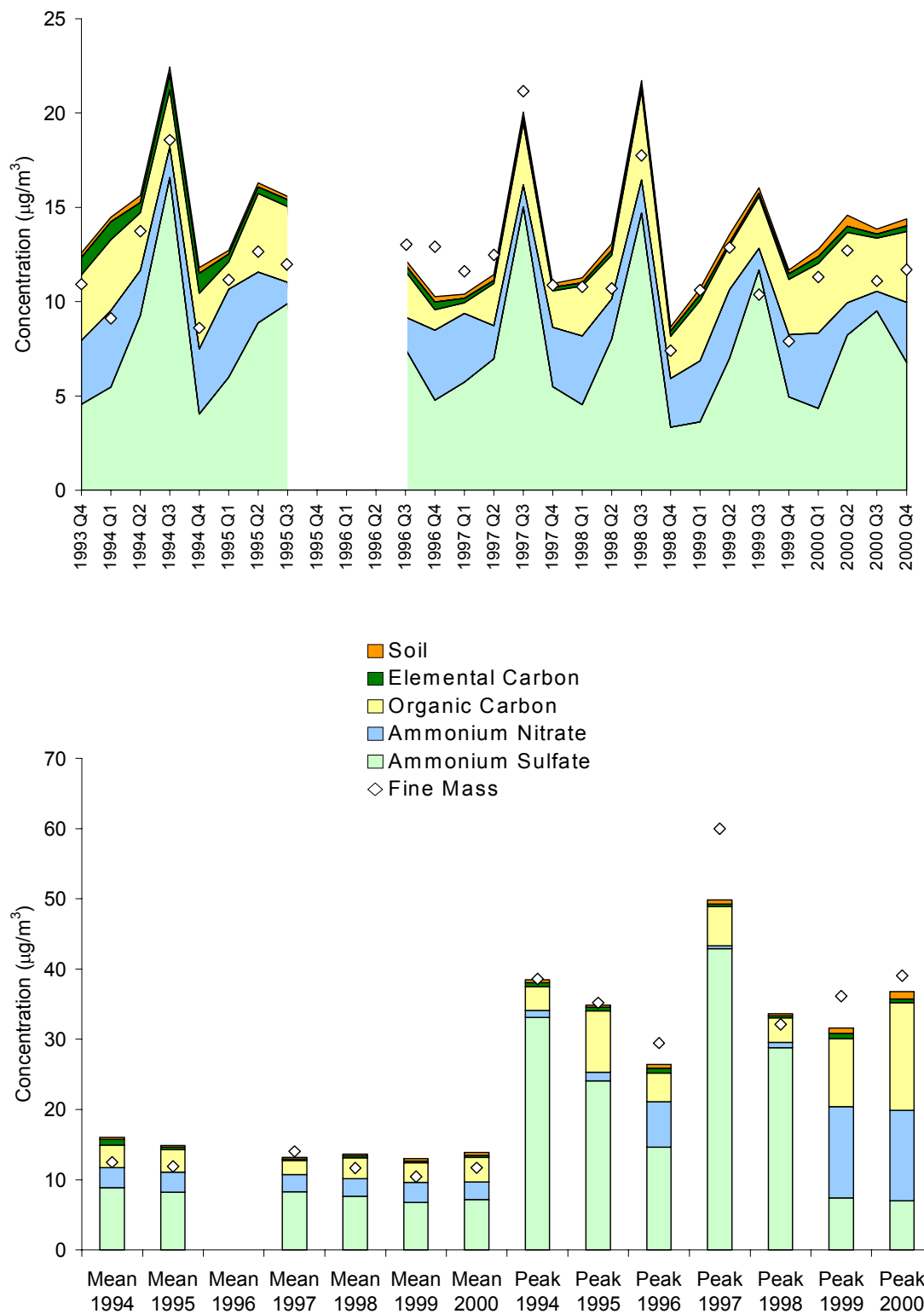
Figure 5-6. Quarterly Mean of Reconstructed Fine Mass ($\mu\text{g}/\text{m}^3$) for 2000

Figure 5-7. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site CTH510



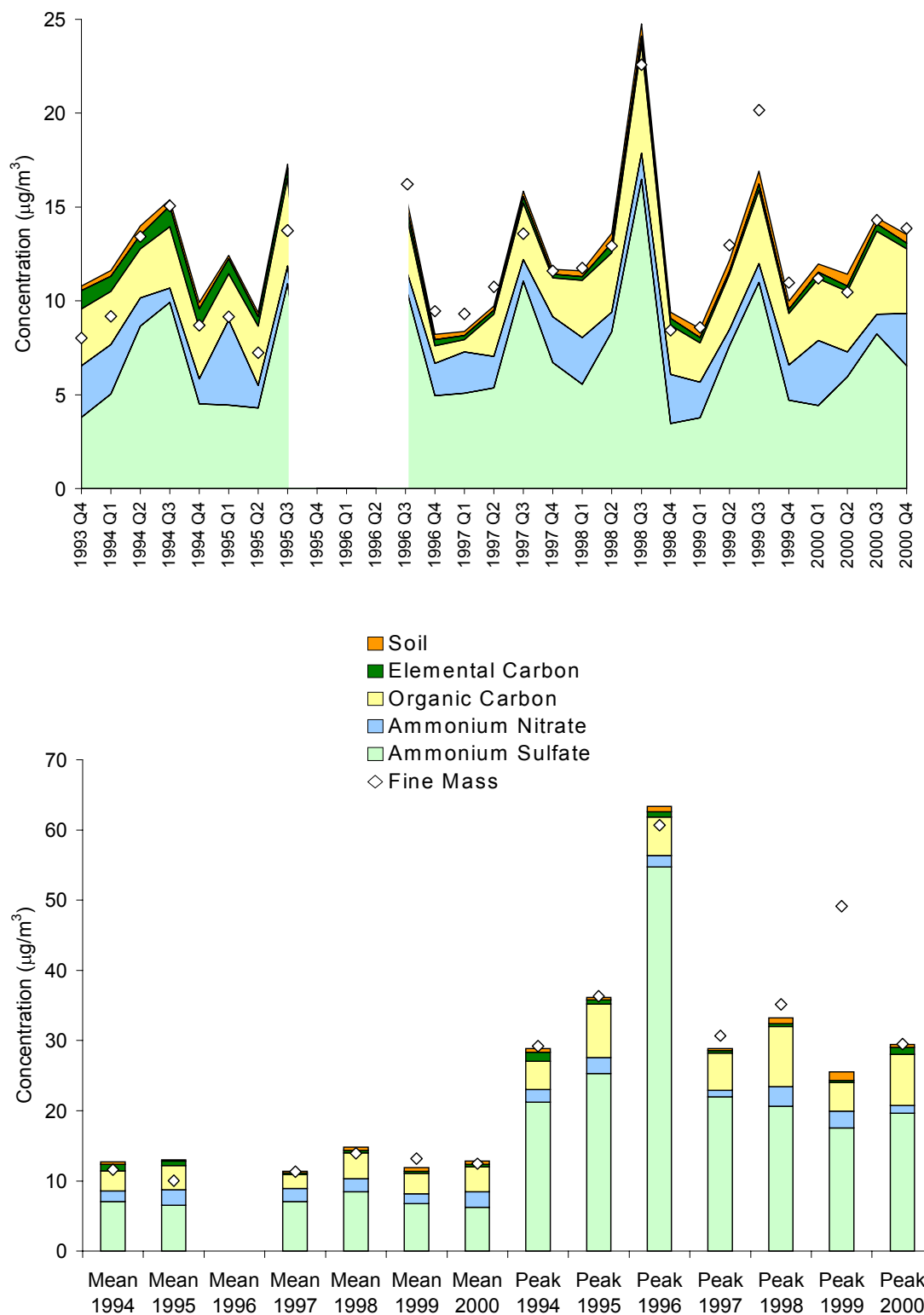
Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. The mean 1995 value was calculated from the first three quarters.

Figure 5-8. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site ARE528



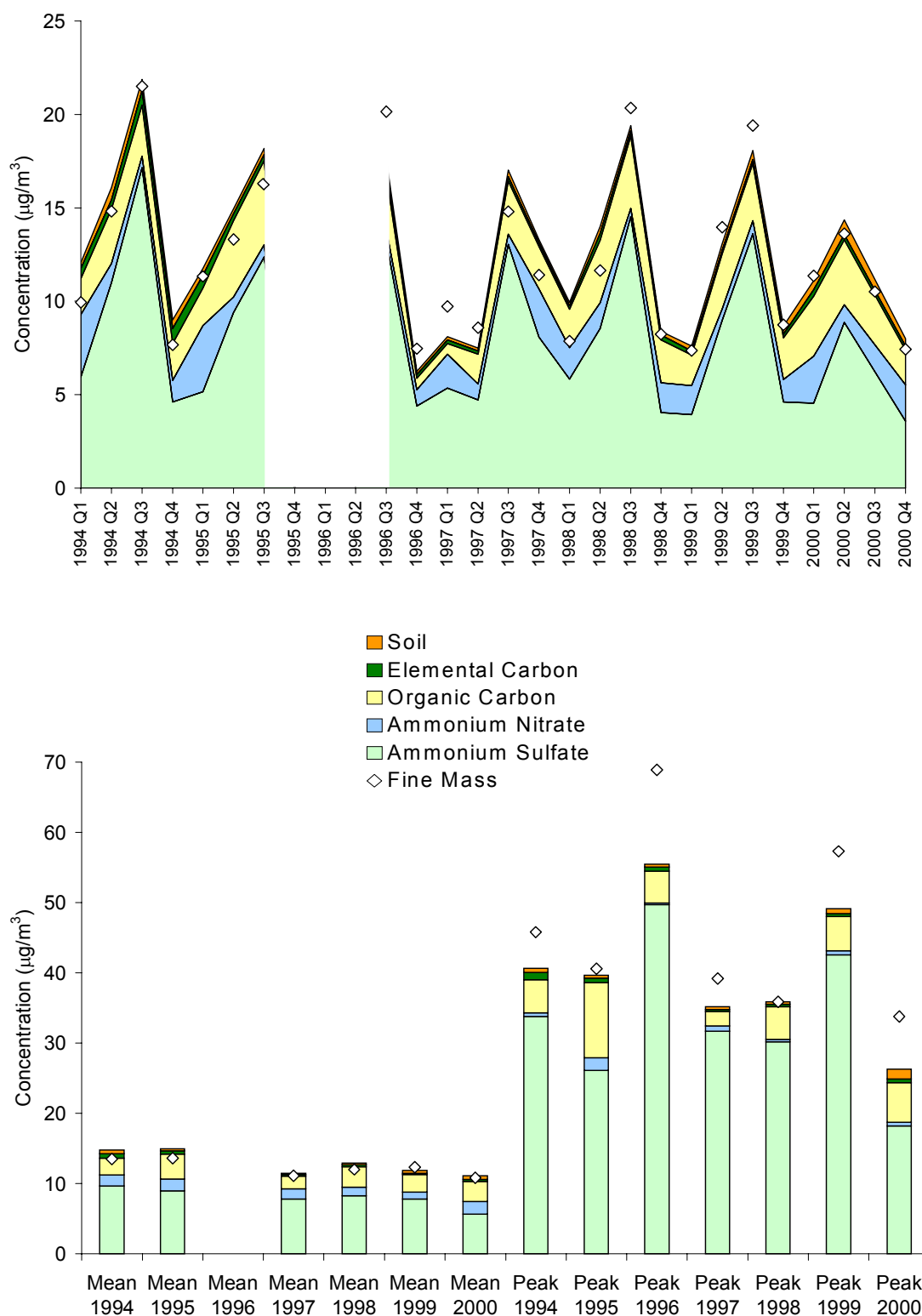
Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. The mean 1995 value was calculated from the first three quarters.

Figure 5-9. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at MKG513



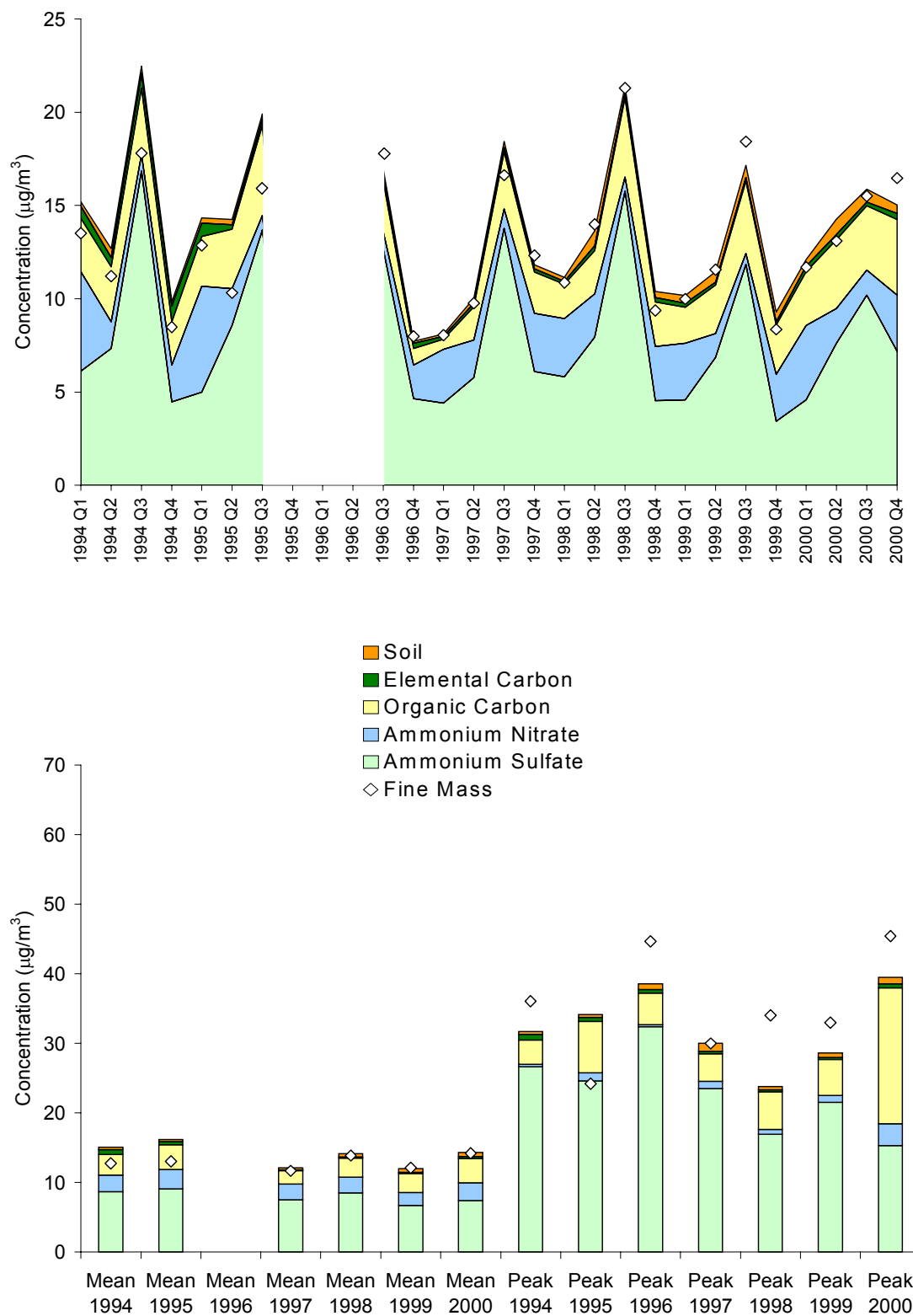
Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. The mean 1995 value was calculated from the first three quarters.

Figure 5-10. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site QAK572



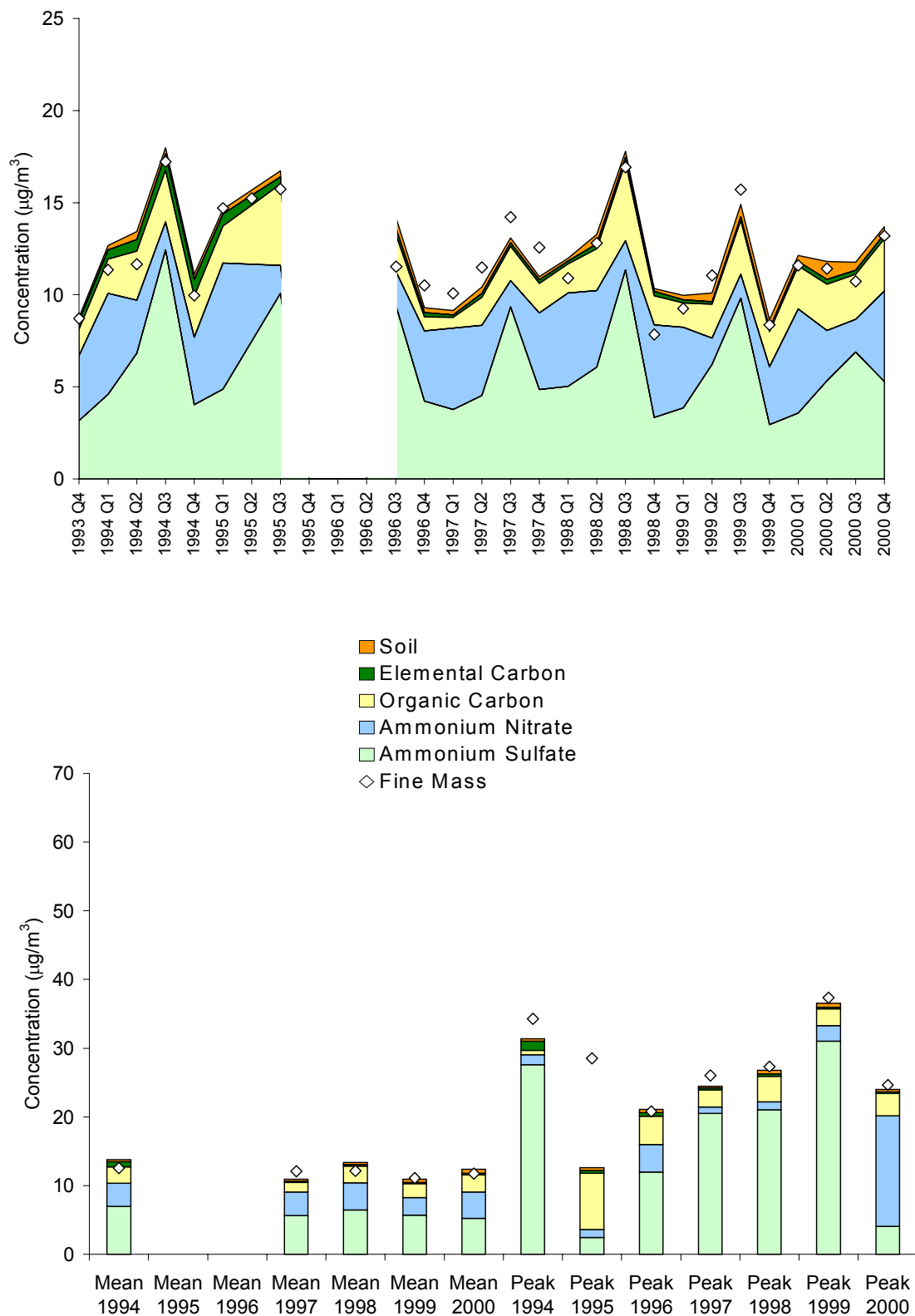
Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. The mean 1995 value was calculated from the first three quarters.

Figure 5-11. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site LIV573



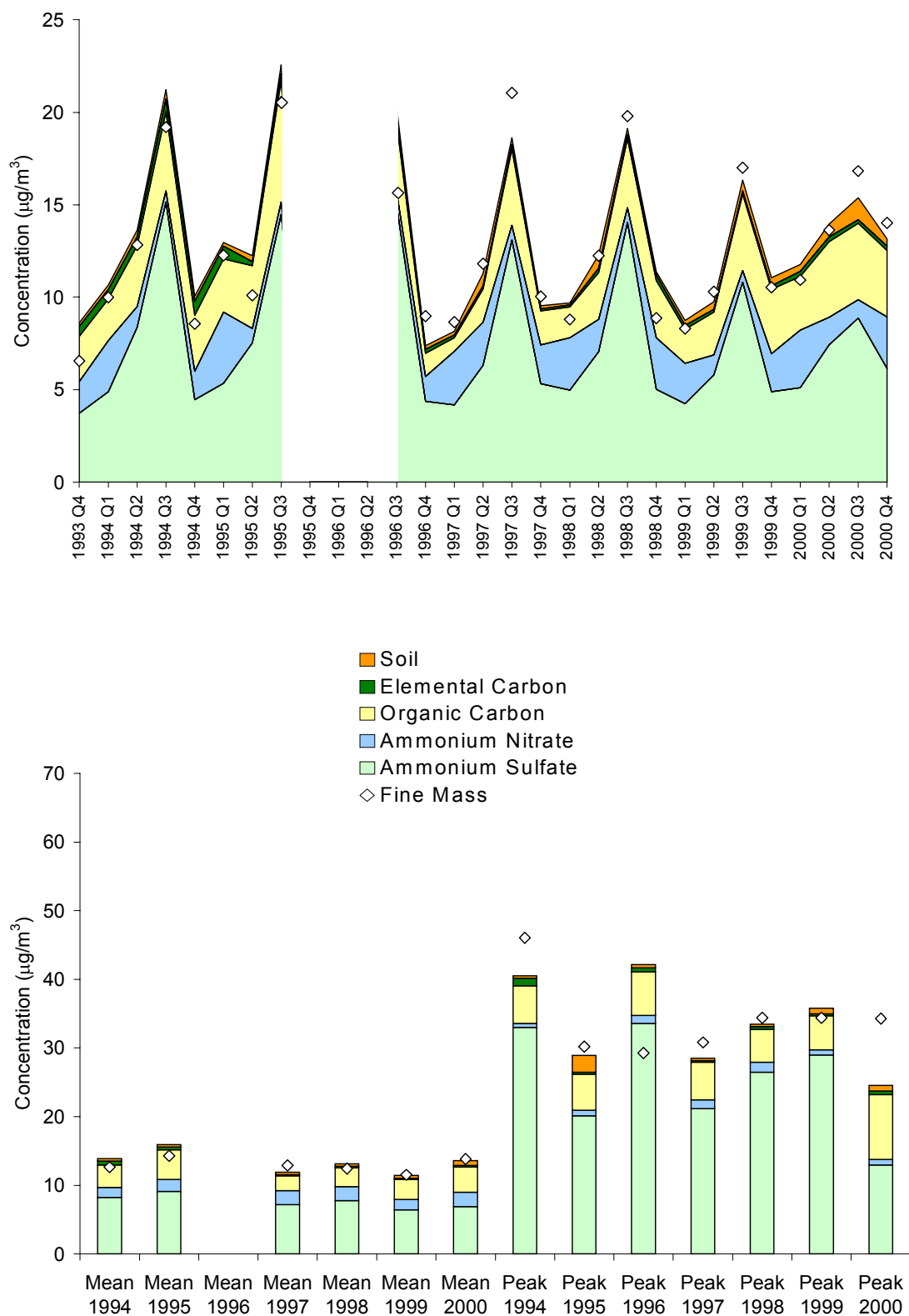
Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. The mean 1995 value was calculated from the first three quarters.

Figure 5-12. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site BVL530



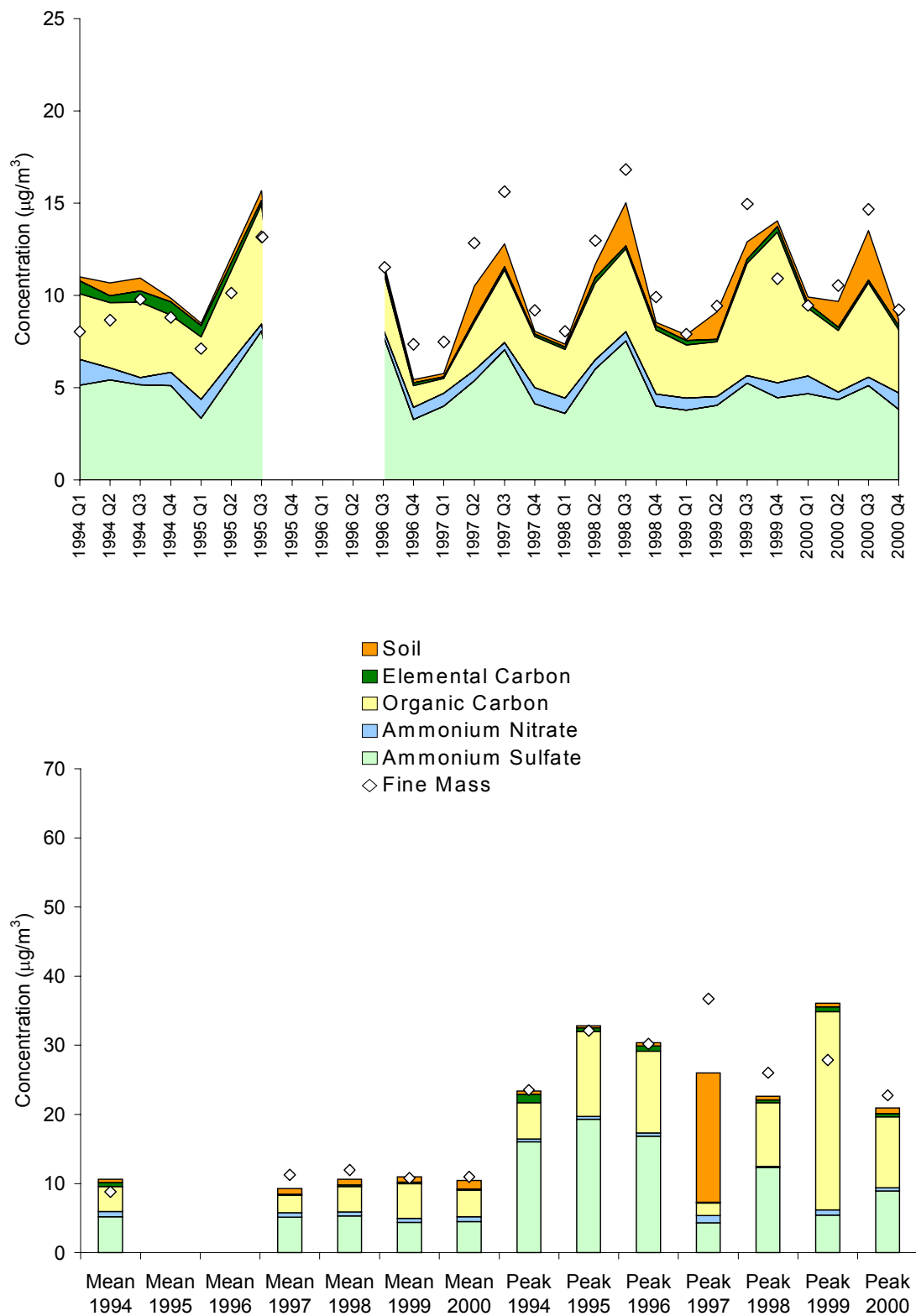
Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network.
No mean was calculated for 1995 because of insufficient data.

Figure 5-13. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site CDZ571

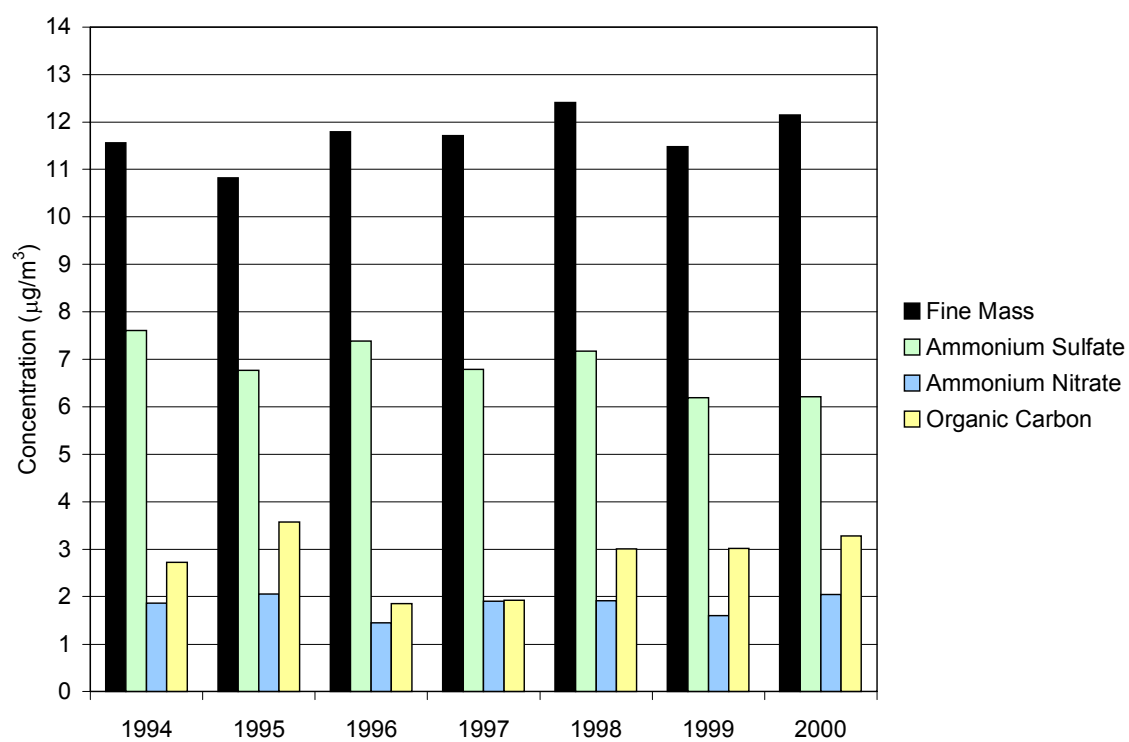


Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. The mean 1995 value was calculated from the first three quarters.

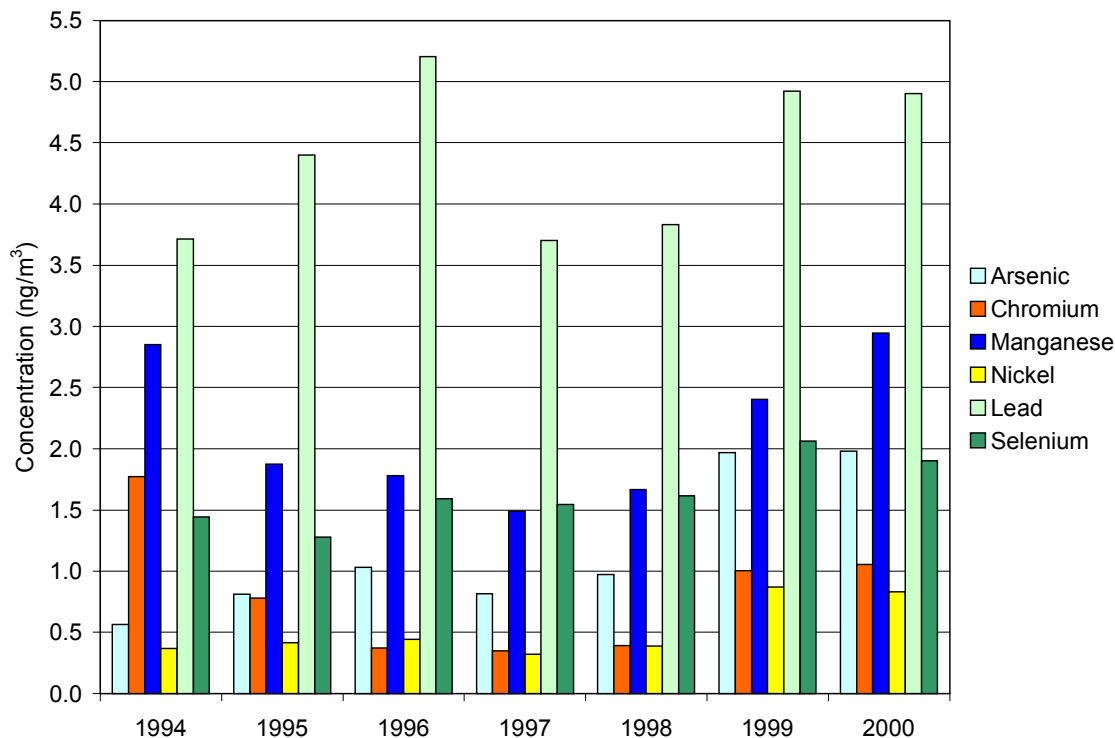
Figure 5-14. Time Series of Quarterly Mean, Annual Mean, and Peak 24-hour Reconstructed Fine Mass Concentrations ($\mu\text{g}/\text{m}^3$) at Site SIK570



Note: Missing data for the fourth quarter 1995 through the second quarter 1996 resulted from the temporary shut-down of the network. No mean was calculated for 1995 because of insufficient data.

Figure 5-15. Annual Composite (8 sites) Mean Fine Mass ($\mu\text{g}/\text{m}^3$) and its Major Constituents

Note: Each annual mean value was derived as a composite of the annual data from all eight sites.

Figure 5-16. Annual Composite (8 Sites) Mean Trace Metal Concentrations (ng/m³)**Notes:**

1. All concentrations are reported with blank corrections.
2. Detection limits are calculated by analyzing 10 blank filters and calculating 3 times the standard deviation of each set of measured trace elements. This value is considered the detection limit, e.g., As 0.158 ng/m³, Cr 0.158 ng/m³, Mn 0.216 ng/m³, Ni 0.116 ng/m³, Pb 0.408 ng/m³, Se 0.141 ng/m³.
3. Concentration values less than the detection limit are flagged with “<” in the CASTNet database. However, these values were used directly in the averages and distributions. All 24-hour concentration values of Cd, Hg, and Co were below the detection limit and were not processed.
4. The 1999 and 2000 sampling were based on filters with a 37 mm deposit surface. Previous years used a 25 mm deposit surface.
5. Each annual mean value represents a composite from the eight sites.

